Route No. 13, North of Kingston

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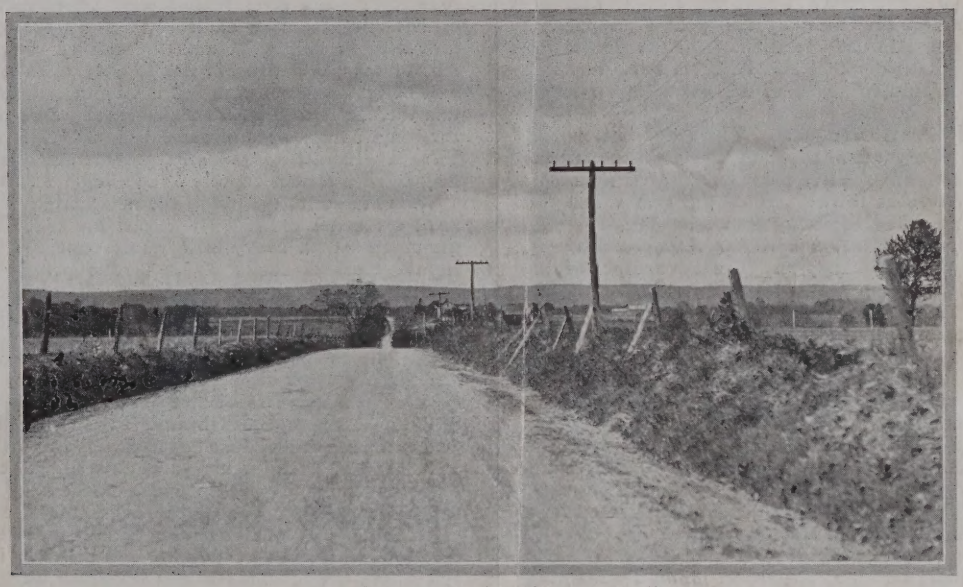


(*Route 16, between Rocky Hill and Harlinger*)

Several of the Eastern States have large mileages of stone and macadam highways. With improved methods of maintaining and re-surfacing these roads, it has been possible to put them in such condition that, with few exceptions, they have stood up remarkably well. (*See page 8*)

Are They on the Job?

When you roll along the road in your car, and after riding over miles of almost perfect pavement, strike a "bad spot" of a few rods, or an old road that has gone to pieces, it is a very simple matter to cuss out the whole Highway System, National, State and County.

But do you ever take the trouble to give fifteen minutes time to know what the men who build your roads are doing to give you better roads?

Read the first article in this Supplement, and learn something.

Note

The papers presented at the recent Convention of the New Jersey Highway Association, and the discussions following them, are such a valuable contribution to the progress of road-building that it has been decided to publish them in full with as many as possible of the charts and illustrations used. (It has not been possible to include all of these, however, so there are occasional references in the text, to photographs and charts which have not been reproduced).

Our aim is to publish one or two of the Convention papers, with the discussion thereon, each month. We suggest that these be carefully filed, so that the reader may keep the complete set, which will make a very valuable addition to his road-building library.

This month we are printing "Improvements Made During 1921 in the Construction of Concrete Pavements", by L. N. Whitcraft, Portland Cement Association; and the discussion thereon at the convention; also "Maintenance of Macadam Roads", by W. A. Van Duzer, Assistant Maintenance Engineer, Pennsylvania State Highway Department; and the discussion thereon at the convention. Next month there will be published "Merits of Bar Reinforcement for Concrete Pavements", by W. S. Edge, Concrete Steel Company and the discussion thereon at the convention; also "The Proper Weight and Methods to Use to Secure the Desired Results with Sheet Fabric Reinforcement for Concrete Pavements", by W. C. Kuhn, American Steel and Wire Co., and the discussion thereon at the convention.

Improvements Made During 1921 in the Construction of Concrete Roads

By L. N. Whitcraft, Field Engineer Portland Cement Association

During the past season those of you who were engaged in the construction of concrete highways found that your specifications and construction details were radically different from those in general use prior thereto. In brief the more important of these changes and their general functions are as follows:

Center Longitudinal Joint. This feature divides the entire pavement slab longitudinally and permits of pouring the full slab width in one operation. The division of the pavement longitudinally increases its beam strength about four times and further precludes the possibility of longitudinal cracks.

Doweling of Transverse Joints. The use of dowels add additional reinforcement at the joints and hold the adjoining slabs in the same relative position. Dowels should be especially effective at the corners of the slab which are naturally weaker than adjoining sections.

Inclusion of Heavy Mesh and Bar Reinforcement—In either Single or Double Layers. The advantages of the heavier steel reinforcement, within reasonable limits, should be obvious for the reason that it gives the pavement greater structural strength and greater resistance to subgrade changes. To more successfully resist both factors it is used, when deemed desirable, in both top and bottom of the slab and in either mesh or bar design.

Laying of a Uniform Thickness of Slab. The weakest point of support of a pavement is at the sides which are usually left unprotected and are subjected to as great a load as is any part of the pavement. It is to secure greater strength, or the same strength at the sides as at the center that a uniform thickness of slab is designed.

Handling of Aggregates Direct to the Mixer Without Same Being Placed on the Sub-Grade. This requirement, of necessity, leads to the central proportioning and loading plant and permits of and facilitates an accurate centralized control of all aggregates direct to the mixer from the unloading plant. The keeping of the sub-grade free and clear from material stock piles permits of more accurate workmanship in the preparation thereof so that with no subsequent obstructions or disturbance the sub-grade should be found both true to grade and cross-section at the time of placing concrete.

At first thought these changes in design gave one the impression that we are getting beyond reasonable economic limits. Such, however, has not proved to be the case. On the other hand each and every feature has apparently well performed the function for which it was designed and without unduly increasing the cost of these highways. Credit for this is justly due both the construction forces and the contractors who so willingly cooperated in an honest endeavor to secure the best possible results under the conditions imposed.

The construction of the center longitudinal joint and the finishing of the groove directly over same has been greatly simplified and perfected by the placing temporarily, of a 2 inch metal cap upon the $\frac{1}{16}$ inch dividing sheet. This cap consists of two $\frac{1}{8}$ in. x 2 in. strips of iron and one 1 in. x $\frac{1}{8}$ in. strip of 8 ft. to 10 ft. lengths riveted together with the 1 in. strip between the two 2 in. strips. With the metal dividing sheet placed upon the sub-grade and coming within 1 in. of the finished surface the placing of this cap upon same brings its top surface to finished grade. When properly staked this permits the placing of concrete and finishing over the full width of pavement. In addition thereto the metal cap so placed gives sufficient rigidity to insure the dividing sheet remaining in a true line and perpendicular to the sub-grade.

After final finishing of surface is accomplished and the concrete becomes sufficiently stiff to hold its shape the metal cap is removed. The edges of the groove so formed are then rounded with an edging tool of $\frac{1}{2}$ in. radius and the groove is ready for pouring with tar or asphalt at any time after the concrete hardens and before the pavement is opened to traffic. Care should be taken, however, not to obtain a groove of greater than 1 in. opening across the top, the reasons for which are obvious.

Doweling of transverse joints by the installation of iron rods is an easily accomplished construction feature. Nevertheless it should be carefully done in order that these rods shall be parallel to both the finished surface and the axis of the pavement. It is also very essential that one-half of the length of each rod is so protected by wrapping that there is no bond with the concrete. Also that a space for longitudinal slab movement is provided at the end thereof. Failure to properly provide for these features may cause a serious rupture or spalling.

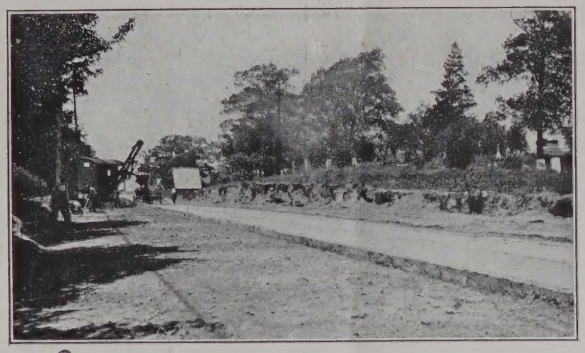
With respect to the use of the new designs in reinforcement far better construction results are to be had in the use of the bar or heavy mesh reinforcement than with the lighter types of mesh. This is due principally to the greater rigidity of the heavier reinforcement and the recently designed methods for accurately supporting same in place by the use of pipes laid upon the sub-grade. Where the double layer of reinforcement is used the accurate spacing apart of the mats is simplified by the use of "chairs" which are fabricated with the mats. Better yet, this can be accomplished by the inclusion of deformed or bent members in the makeup which serve as "spacers" and have a definite reinforcing value as well. These methods of supporting and spacing apart of the double layer of fabricated mats have one great advantage in that this so-called "cage" of completely fabricated double layer reinforcement permits of pouring the concrete in a single full course depth. This is also a distinct advantage over the old practice of placing a course of concrete then a layer of reinforcement followed by another course of concrete, especially when dry concrete is used.

Uniform thickness of slab requires no different construction than the pavements of greater thickness at the center than at the sides, other than in the former sub-grade is shaped to the specified crown, which is usually 2 in. or less, while in the latter the sub-grade is flat. The impression prevails that the crowned sub-grade is preferable to the flat one principally because of the fact that it drains off and dries out more rapidly after a rain. This is a desirable feature in connection with progress and the preservation of good sub-grade conditions.

No one feature in the construction of concrete highways has been productive of more highly desirable results in character of workmanship and quality of these highways than that of keeping the aggregates off the sub-grade. As a result we now find anywhere from one to twenty batch units being delivered to the mixer all proportioned accurately alike which makes for greater uniformity of concrete. The properly prepared sub-grade, at all times unobstructed, should insure the required thickness of pavement at all points. With this requirement in effect one can readily tell whether or not the specified thickness of pavement is being placed. Another feature is the facility with which the sub-grade can be restored to its proper condition in case of disturbance by rains or other causes, such as the development of weak spots due to unsuitable sub-grade material which it may be necessary to remove.

While these features, above mentioned, have undoubtedly brought about a very noticeable improvement in the construction of concrete pavements, and will add very materially to their life, there still remains room for further improvement to which I desire to call your attention.

The thought prevails generally that heavily reinforced concrete pavements do not crack, and it has been with a view to eliminate cracks that the reinforcement feature has been given so much consideration. Admitting that



Building a road half at a time in order to maintain traffic. (Route 4, Sec. 3-A). Convenient for the motoring public, but it adds to the cost as the machinery and building crew have to go over the same ground twice.

this effort has met with a great measure of success, we must at the same time acknowledge that the results are not quite up to our expectations.

It is a generally accepted theory that cracks are due to frost action, changes in temperature and unequal bearing power of the sub-grade. Yet if these were the only causes the heavier designs of reinforcement would serve to more nearly eliminate them.

From an observation of the methods of construction of these pavements I am led to believe that the most successful and effective method of eliminating cracking is the use of reinforcement together with the *proper protection and curing of the concrete during the early hardening period.* It is during this hardening period, when the concrete has little or no strength to resist shrinkage, that transverse or shrinkage cracks occur. It is also during this period that the reinforcement is of little or no value, for there is no bond until the concrete hardens.

To offset this shrinkage, sometimes called contraction, during the period between the time the concrete is placed and the time it sets, and has strength, it is absolutely essential that effective curing be had immediately following the time of final finishing of the surface in order that this cracking might be eliminated. The development of this cracking as a result of too rapid drying out and ineffective curing is far more apparent in long length slabs than in the shorter ones. It would therefor seem that the slab lengths should be greatly dependent upon the effectiveness of the curing to be done.

Another advantage to be gained as a result of effective curing is that concrete properly cured by being covered and kept constantly moist as provided for in your standard specifications will show much more compressive strength and much less wear than that which has been allowed to dry out too rapidly. It is true that any and all factors that tend to produce strength in concrete also tend to increase its wearing qualities. As an illustration of this, at the end of 4 months the compressive strength of a concrete of a given consistency was about 1700 pounds per sq. in. when it was allowed to dry out in the air unprotected, while exactly the same concrete stored in damp sand for the first 21 days gave compressive strength of about 4000 pounds per sq. in. and a correspondingly less wear in the rattler tests. In short, proper protection and curing for a period of 10 days means an increase in strength and resistance to wear of appproximately 100 per cent.

With knowledge of this kind as to the possible increase in strength and resistance to wear to be had through so simple a method as effective curing for so short a period as ten days, why should we throw away one-half of the life of concrete highways by failing to observe this rule.

Discussion on Improvements Made During 1921 in the Construction of Concrete Pavements

By J. A. Williams, Southern Division Engineer, New Jersey State Highway Dept.

Mr. Williams: Mr. Chairman and Gentlemen. I have listened with much interest to the paper of Mr. Whitcraft, and will say that within the last month I have spent most of my time listening to a series of lectures on Highways at the University of Pennsylvania. This course at the University was based mostly on the practices of the State of Pennsylvania. When we enrolled for this course we were instructed to buy a book written by a man by the name of Agg from Iowa. Most of us that got the book read it over the first night and heartily disagreed with it. We went back to the University and listened to lectures by the Chemical Engineer of the Pennsylvania State Highway Department, the Engineer of Construction, and the Engineer of Maintenance, and found, to our surprise, that they also disagreed with that book. We men from New Jersey that listened to their lectures came to the conclusion that we disagreed with what the Pennsylvania men told us. Mr. Whitcraft's paper outlined what is practically the policy set last year by the New Jersey State Highway Department. In fact I am sort of in the stage of what a lawyer friend of mine told me about a jury. The jury was called in the morning. The prosecuting attorney gave his story, called his witnesses and the case adjourned for dinner. In the afternoon the attorney for the defense stated his case and called his witnesses. The jury discussed it among themselves and the Foreman of the jury got up and said: "Your Honor, is it necessary for us to listen to any more testimony? Before dinner I had a very good idea of how this case stood and I think the rest of the jurymen were in about the same state of mind. Since dinner the testimony has been more or less conflicting. If you would call the case to an end right now, we could retire and give a quick intelligent verdict, while if we wait to hear any more testimony, I doubt if we ever reach a conclusion." I don't mean by that that we should not listen to Mr. Whitcraft's paper or to the lectures of the men from Pennsylvania, or that we should not agree with Mr. Agg's book. I understand that Mr. Agg had considerable to do with the making of the good roads in Iowa. I know there are good roads in Pennsylvania. I

also know that there are good roads in New Jersey. I, therefore, believe that the greatest thing in getting good roads is to set a policy, and stick to that policy. I think there are very few things, no matter what they are, but what there is more than one way of doing them. That is brought out by the placing of reinforcements in pavements.

Pennsylvania uses a slab with a flat bottom about 9 in. center of thickness and 6 in. side thickness, similar to what we used a few years ago. They place expansion joints at all breaks in the grade but not less than 200 feet apart, and place reinforcing in the top of the slab. New Jersey, a few years ago, used no reinforcing. Good roads were built that way.

At the present time our policy is practically as outlined by the paper of Mr. Whitcraft. I believe, gentlemen, as most of you are interested in work in New Jersey that you should carefully look over the specifications of New Jersey. At first reading there will be many things with which you will disagree. At the second reading, you will find most of these things are just as you thought they should be in most instances, and that there are some other things that you can't agree with.

I believe our best interest is to get good roads in this State. If we believe that the policy as set by our State Highway Department and by the Counties in their work is the proper policy to follow and follow it right through, we will get good roads. However, if on the other hand, you are a contractor and when you bid on a job you look over the plans, specifications, etc., and say, "Well, that is a hell of a set of plans and specifications, I can't think of anything good to say about them, however, I need the money, let's go to it," you will throw the plans and specifications in the corner somewheres and go on the job. Perhaps the equipment you take is suitable, perhaps it isn't. However, that is your equipment, and you are going to use it. I think that is the wrong attitude entirely. You should carefully read over the plans and specifications and see if you can make yourself agree with what they outline, and if you don't agree, see if you can't do it anyway.

On the part of the inspector, you should very carefully study the plans and specifications and consider first that the man who wrote the specifications and made the plans probably knew a little bit of what he was talking about or what he put on the plans. Some of us on the road often wonder how the fellow who made the plans holds down his job. Possibly on the other hand, he should wonder how we hold down ours, and if we used a little more self-analysis instead of quarrelling with the other fellow, the results might be a little better.

In this matter of agreeing with the plans and specifications, last summer I heard a couple of engineers talking about a couple of jobs built within the last three years in the State of New Jersey. These jobs were what you might call identical jobs. They were in the same county, abutted on each other and the specifications were exactly the same. The plans were supposed to fit the locality. One job was a pleasure to be connected with. Everything seemed to run smoothly. The job was finished nearly on time. The other job was sort of a battle royal all the way through. The contractor would not agree with anybody and would buy almost anything that anybody was willing to sell to him. He could not see why anything should not go into the road. Sand is sand, stone is stone, and cement is cement. Whether it was mixed with sand, clay or loam, it did not seem to bother him much. The same material that he was using was going into the Ritz-Carlton Hotel and we all know what that is.

It was good enough for that, it must be good enough for the road. On the other hand, the other fellow seemed to want to get along, and anything you suggested he seemed willing to do. I understand the man who was willing made money. At least he says he did not lose any. (I never yet heard of a contractor who made money). The other man says he lost money and I think he did. If he had tried to enter into the spirit of the game a little more, he might have broken even. The one job has cracked, and never did have the appearance of a good one, while the job that did make money for the contractor is a very fair job today.

The conclusion is that the first man who made money mixed a little brains with his concrete.

I do not know what the other man mixed with his concrete. I think he came as near the specifications as we could force him to. However, most of the specifications are sadly lacking in the requirement for brains. By that I do not mean to say on the part of the men making the specifications, but in requiring the people who use the specifications to have brains. You can call for good materials and good workmanship, but if you do not have brains in the work you have my sympathy. I don't believe you will have good results. It's something like the story of Mrs. Newlywed who said to the grocer, "You sent some flour yesterday that was awful tough. I made a pie with it and you couldn't pull the crust apart." There is no question but what someone else got some of the same flour and made a good pie with it and called it nice, tender flour.

I will say, in closing, gentlemen, that the main thing to be considered in all of this work is the fact that first, if we want good road, we should outline a policy and stick to it. If your policy is wrong, the policy can be changed next season, but you should not, every time you come on the job, try to tear it apart and have the engineer make a new set of plans. If the inspector thinks it is wrong, he should try to have it done the way it was designed to be done, and try to believe that the fellow who outlined the thing in the first place probably knew a little bit about it.

In starting this discourse I mentioned Iowa, Pennsylvania and New Jersey. All have good roads, and all have a policy. I believe their policies are all different except for the one fundamental fact, that they want good roads. Iowa is getting it through its policy, Pennsylvania through their policy, and we have been getting it from ours. I believe, gentlemen, that the thing to do is to study your plans and your policy and try to enter into the spirit of the thing and then you will be surprised at the results. I thank you.

COL. WHITTEMORE: I would like to call your attention to the fact that this discussion is on concrete pavements, and I would ask that you confine your questions and remarks to that subject. The time is limited and important papers are to come before you.

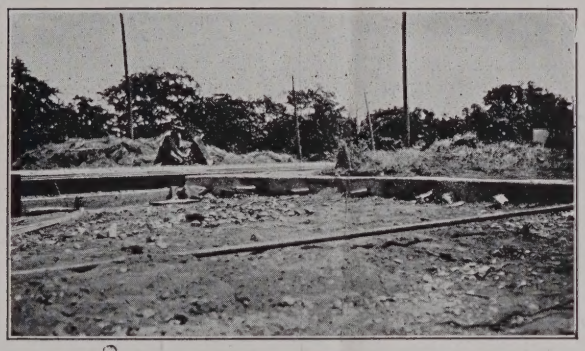
I would like to make this comment, with which you are doubtless familiar, but which we sometimes lose sight of, that in the process of making concrete with cement, sand, and stone, you speak sometimes of the material drying up. That is, subjecting the material to influences that are absolutely detrimental. The setting of cement is a chemical process, and the more you can completely exclude the air the better the results. For a great many generations we have been familiar with lime mortar, which depended upon contact with air for setting qualities. We do know that a lime cement in contact with air, hardens quickly and loses strength. You can break some walls from 20 to 24 in. thick that have been standing 15 or 20 years, and you will find that the air has been so completely excluded from the heart of wall that the mortar is still soft since the carbonic acid of the air has been completely excluded. In cement work ,if water or other substances are used to exclude the air, the better that product will be for you to have it set with the air completely excluded. In some places where the roads are comparatively level, they build dams around the road and flood it with water. You should keep very clearly in mind that the more you exclude the air from the concrete the better the results are going to be.

MR. ROBBINS: Mr. Whitcraft spoke of an effective slab length. What did he mean by that?

MR. WHITCRAFT: I do not just understand the question.

MR. ROBBINS: Did you not speak of an effective slab length?

MR. WHITCRAFT: The point made is this, that the length of the slab should be dependent upon the amount or effectiveness of the curing that is to be done. I cannot say build a continuous slab length of 200 feet and not have a crack develop in it. You may go out and lay a 200 ft. length slab and leave it unprotected. This has been tried out repeatedly without producing a crack, sometimes it will produce two or three. On the other hand, I believe you can successfully lay the longer length slabs without these cracks if you can follow up the final finishing of the slab by covering it and keeping it damp and moist. The



This shows you how one slab is joined to the next. (Route 4, Sec. 3-A). The bars sticking out of the concrete are wrapped with tar paper. This allows the next slab to expand and contract without cracking, but prevents it from raising above or settling below the first slab.

one should be dependent upon the other. I have in mind a particular point that was raised in connection with two slabs in one of your last year's State Highway contracts. I had my attention called to the condition of these slabs in this job. They had several cracks and the road had not even been opened to traffic. It was thought that there should be a change in the specifications by the Highway Commission. I asked what length these slabs were. The men did not recall. I said they were about 600 feet in length. He said no. As a matter of fact they were. In one particular slab 600 feet long there were from 18 to 20 transverse cracks approximately 10 to 11 feet apart. This slab showed these cracks before traffic during the summer season. There were no extreme changes in temperature, so you cannot say that the slab cracked up from traffic or sub-grade temperature changes, but these cracks simply developed by too rapid drying up of that long length of slab. They were contraction cracks. I feel, on the other hand, that while probably the extreme length of slab is bad practice to construct, if you want to eliminate it, I believe it could have been constructed without cracking if covered up to prevent drying out following the final finishing up.

MR. ROBBINS: I will change the question. Under ideal curing conditions what would you consider a minimum slab length? Does the slab length bear any relation to its width? What is the proper proportion of width and length?

MR. WHITCRAFT: I do not know, and I do not think anyone else does. I can't tell you on that basis, but go back to the other statements. I believe in designing these slab lengths, we should take into consideration the length of the slab you design and how well you are going to cure it. I do not think it is fair to the public that they should pay for these roads or the material going into the roads, if we are going to let so simple a feature of construction as curing—so cheap a feature—be neglected and the road allowed to develop these cracks, which we do not want in the roads. I think that one of the main reasons that more effective curing is not done is that it is evidently such a trifling matter. A contractor thinks he can take care of it at the end of the day and has not got time to cover it up and sprinkle it. We have never attached enough importance to this one feature, and it can be shown by tests that concrete develops 100% more strength by the curing methods described today in your specifications, and I believe it is just as essential to properly cover it and cure it for ten days as it is to put cement in it.

MR. ROBBINS: Yes. Has your Association ever made serious investigations to determine the proper proportion between the length and width of the slab?

MR. WHITCRAFT: I believe not. I cannot think of any way you could dope out the proper slab length by showing any relation between the length and width of it. It might be that you can.

MR. ROBBINS: It seems that there should be such a thing in a rational design.

MR. WHITCRAFT: That is more or less an arbitrary design. Your specifications calls for a slab length of not less than 50 feet nor more than 85 feet. I think that is a very reasonable distance, but even with the 50 to 85 feet slabs, if you don't cure them right, you will develop contraction cracks.

MR. ROBBINS: The cracks are due entirely to curing?

MR. WHITCRAFT: 95% of these transverse cracks are due to too rapid drying out. The same thing occurs with clay. When the water drains off, it will very shortly crack up. That is nothing but shrinkage.

MR. ROBBINS: In your paper I note you made reference to reinforcing and not curing as being the proper solution for cracking. Would you hold that true as a guard against cracking as against uniform sub-grade conditions?

MR. WHITCRAFT: I think sub-grade conditions eventually have an effect on the stability of your slab. We all know that changes in sub-grade, due to moisture content and frost action, will very frequently crack a slab. I believe that is to be overcome in the use of the proper amount of reinforcing. I do not believe that we can altogether overcome it, however, but we do know that the reinforcing value lies in the prevention of a great number of cracks and it further prevents cracks from opening up and holds the slab at the crack the same as dowls at the joint.

MR. ROBBINS: We are assuming a great many factors. We have to assume arbitrarily the length, the thickness, and width, and I would say that in the design these three factors should bear some relation to one another outside of arbitrary selection. Do you know of any attempt of your Association to determine any relation between the three?

MR. WHITCRAFT: That is practically the same question as the other. I do not believe there is. You say the width is established arbitrarily. Pavement widths are certainly based on something we know a whole lot about.

MR. ROBBINS: Then we divide this in two by a center joint. Therefore, again making an arbitrary width of slab. If you want an 18 ft. road, and cut it in two you have a 9-foot slab. Would you, therefore, if we were making a 27-foot road, make three slabs of 9 feet each?

MR. WHITCRAFT: No.

MR. ROBBINS: Why?

MR. WHITCRAFT: No reason particularly.

MR. ROBBINS: Why isn't it reasonable to divide a 27-foot slab into three parts?

MR. WHITCRAFT: What is the advantage? The reason is an 18-foot pavement is divided in half by reason of the center longitudinal joint. There are several. One of the principal reasons is the fact that when you have a 20-foot width of road, by dividing that slab in half you increase the transverse beam strength about 4 times, and preclude the possibility of longitudinal cracking by the reason that you build your crack in a straight line down the center of the road. These are the essential reasons and I think they are well justified.

MR. ROBBINS: What is the percentage of longitudinal cracks?

MR. WHITCRAFT: That varies. I have seen quite a few in old roads. They are very unsightly and very undesirable. I think there is another point in favor of the center longitudinal joint, and that is its effect on traffic. It is

well justified in that respect if for no other advantage. It makes safer driving. If you have any arguments against it, what are they?

MR. ROBBINS: I was just wondering why, if just for some psychological reason, as you mentioned, that we create a condition every 100% of the distance when it does not occur from my observation over at least 10% of the distance.

MR. WHITCRAFT: I won't dispute your figures in that respect.

MR. ROBBINS: I can see your reason for increasing the beam strength, and then there is the factor of depth which we choose arbitrarily. Thank you.

MR. BRAGG: The matter of curing concrete is such an important one not only from the effect of stopping the cracks, but the quality of the concrete secured all the way through that I wish to endorse what Mr. Whitcraft has said about improving the quality of the concrete by curing. I think that if we have a weak point in our construction anywhere this may be one of them, and there isn't any question whatever of the benefit to be received by careful curing of the concrete surface. The only reservation I would make on Mr. Whitcraft's statement is, whether the slab is 150, 200 or 2 feet long, I would use the best method of curing that we possibly can use. It is not alone to prevent surface cracking, but it is to add also strength, and therefore, add to the wearig qualities of the pavement.

MR. ROSELLE: I have got something on my chest which I have just got to get off. To my mind there are three things which go to make up a road—a good road. Money, intelligent theoretical application, and intelligent practical application. I was glad to be able to listen to Mr. Williams on his discourse. He brought out the point that to produce roads we must outline a policy. That is true. We have a policy. I am glad to listen to Mr. Whitcraft because he brought out one of the vital factors commented on by Mr. Bragg, and that is the curing. I am prone to believe that too much stress is laid on the first two factors. Money—we are trying to get it here. We must have it before we can have the roads. We are laying a lot of stress on theoretical application. We are, right now at this moment. I am not sure that we lay stress on practical application, and Mr. Whitcraft's talk about curing brings out that point. You can write in your specifications and plans the policy of the use of theoretical application, but you have never seen a bricklayer that can paint a picture. Very few of them ,at least. You can't take a man out of the foundry, who has never done concrete work, put him out on the road and expect him to get the cooperation and respect of a contractor on a concrete road, and I would like to ask Mr. Whitcraft if he does not believe that practical application isn't sadly being neglected in all states, leaving Jersey out.

MR. WHITCRAFT: I would answer that by saying that you pay the contractor for practical application.

MR. ROSELLE: As brought out by Mr. Williams, the contractor is on a different side of the fence in the game for good roads. The State Highway Department is the one mainly interested in good roads. I do not make that a specific application. There are contractors and contractors. A contractor, should, of course, if he is advertising his business, turn out a good road, but lots of times he isn't advertising his business, but filling his pockets; that is the game he is in.

MR. WHITCRAFT: I do not agree with you. We are all filling our pocketbooks. When you say the contractor is not in it for good roads but the Highway Department is, I disagree with you altogether on that point. The contractor is in the road building business, and is just as much interested in good highways as your Highway Department or any other Highway Department is. Once in a great while there is an exception. I see them more quickly than any of you do, but I understand that 90% of the present contractors busy in building roads in Jersey today are just as much interested as you are. Why not? A contractor's business is his livelihood and life's work. I believe that ultimately good results in highway construction are to be had more through successful cooperation between the Department employees and contractors and material interests than in any other way, and as Mr. Williams says, unless you have intelligent cooperation you can't produce results. We must all get together on common ground, work with the same object, and it can be better obtained through successful cooperation. 99% of the contractors are willing to give it to you. From my observation during last year's construction throughout the entire State of New Jersey, the one thing that impressed me most was the wonderful spirit of cooperation on the part of the contractors with the Highway Department and vice versa, and I think it shows good results. There is nothing I want to see more than the feeling of fellowship among the interests concerned, but do not get the idea that the contractor is not interested in highway work.

COL. WHITTEMORE: We are wandering considerably. The subject is not integrity of contractors, but as you brought it up I might make a few remarks. I think, without fear of contradiction, that I have had more experience with contractors than anyone in the room, since '79 as engineer in charge of all kinds of work, building railroads, sewers, municipal improvements, immense steamship terminals, bridges, and some of the largest water-works in the country, and I have never yet found a contractor who was engaged in any other method of doing work than to do a good job in accordance with the contract, the specifications, and the direction of the engineer. There are men before me this morning who were working for me on contracts 31 years ago and making money with excavation at 27c a yard, so I think it is a libel against the good name of these contractors for anyone to voice any sentiment to the effect that they are there to beat the specifications. I do not think it is a fact, and I wish to voice my protest personally against such an insinuation. There is a great deal of difficulty due to a great many things not referred to. The policy so called is not in the specifications. Those are distinct requirements controlled by those in charge of the administering of the money. The specifications are made in accordance with experience and conditions prevailing. With reference to concrete pavements, if you will always remember that in the setting of cement in order to develop its strength, it is absolutely necessary to have moisture present and if this moisture be taken out of the mixture, its strength will be lowered, because it does not have a sufficient amount to develop its strength, you will eliminate many of your troubles. With reference to the question of width of slab, and as to why the center joint is made, I won't undertake to say why they are made, but I do say this, that I believe I was the first one, after being appointed on the Commission, to call attention to the fact that the center of our old highways were where everybody travelled and comparatively narrow tracked. Everyone travelled in the middle of the road. The roads with high crowns got rid of the water but it was awkward to travel on the side. We began to build improved roads and make them wider. The sides are not as hard as the middle and there is a tendency for the sides to settle and the middle not to settle, which causes a crack. If we put a joint there, we get a crack and make it straight. Under the effect of light or shade, heat and cold the concrete is rising and falling, so that it at times is absolutely free from the sub-grade and if there is a joint in the center it acts as a hinge, and if kept filled with pitch or bitumen, it will keep the water out.

With reference to the length it is not a question of arbitrary policy or guess work, but you will note that the ratio of expansion of concrete within the practical limits is about the same as steel, 7 millionths of its length for each degree of temperature, that is about ¾ in. in a hundred feet. Your concrete is going to expand with the heat and contract with lowering temperatures, but not to the extent indicated by the change in temperature. The amount of expansion you have to provide against in concrete is not as great as is indicated by the temperature, because in contact with the ground a great deal of heat is absorbed. An example of this is the making of continuous track by welding the rail joints of trolley tracks. About 25 years ago an experimental track one-half mile in length was laid with dirt brought up to the level of the top of the rail. It was subjected to the extreme changes in varying temperatures of summer and winter. There was absolutely no change in any portion of that track of 7 in. rail. The expansion and contraction was not greater than the elastic resistance of the rail. The

rail was then exposed to its depth for a distance of 15 or 20 feet and was later found 2 feet up in the air. I beg your indulgence for these few remarks in answer to the questions that you have asked.

MR. GAGE: Since the subject of this discussion is Concrete and there are a number of contractors present, I would like to state that the Department has made several changes in the 1922 specifications covering the construction of a concrete pavement. Since these changes affect both the aggregate and the method of constructing this pavement, it is suggested that contractors examine the 1922 specifications very carefully before placing bids for work to be constructed under them. The preparation of the sub-grade has also been changed. In the past, it was assumed that the contractors would make the necessary effort to prepare the sub-grade in the manner desired or required, but the Department has found that they frequently took advantages of the liberty thus offered and did not properly grade or prepare the sub-grade. It has been the usual custom to only prepare the sub-grade as fast as the mixer was moved and it was very seldom that a subgrade was properly wet before the concrete was deposited thereon. The work of our core drill has shown the damage that has been done to our pavements by not having the sub-grade properly prepared.

The 1922 specifications require the sub-grade to be prepared at least 400 feet in advance of the mixer, also to be wet at least 50 feet in advance of the mixer. The final finish has to be secured with a mechanical finisher resting upon the side forms. The manner in which the subgrade is to be sprinkled is definitely defined and the depth to which the water must penetrate for each type of soil is also specified. Again, there is no doubt but that considerable strength of the concrete has been lost by not having it properly cured. To remedy this, more specific requirements have been used regarding the curing of the concrete. Personally, I do not think a contractor should be paid for a concrete pavement if it is found that the concrete has not been properly cured and allowed to dry out at frequent intervals during its initial life.

As to the length of the slab, experiments have shown that the number of transverse cracks increased as the width of the slab decreases which is to be expected.

In regard to the proper distance to place joints, will state we are subjecting our highways to causes which produce these cracks. As soon as we have these causes properly defined or eliminated, we can no doubt establish a definite length of slab which may differ considerably from that which is in ordinary use today.

MR. BURKE: It is rather amusing to hear Mr. Gage representing himself as the State. I would like to ask Mr. Gage if by inserting these things in specifications, whether he could come out and apply these different things they impose on contractors, meaning a mechanical sub-grader. This would mean buying more trucks at an additional cost of several thousand dollars. It is compelling the contractor to use a mechanical sub-grader and put other equipment that he has, out of use. You cannot get in on the sub-grade if the sub-grader is at work. I do not think that it is fair to add that expense to the contractor or the cost of the work. I would like to ask Mr. Whitcraft if he advises the same thing in the field as talked of in theory. I will answer by saying, no. On the job Association men come and find fault and ask the contractor why he doesn't do so and so. We tried this out once and the job got all mixed up. The Contractor had to straighten the job out and not as much concrete yardage was laid before as afterward. Theory is one thing, but theory should not interfere with practice. Theoretical men on the job should not interfere with the contractor. The state has inspectors to interfere with the contractors.

MR. GAGE: I do not know where or how Mr. Burke acquired the idea that I was assuming to be the State of New Jersey or the Highway Department. I simply stated the improvements that have been made in the 1922 specifications, which are facts. These changes were not made by me, but represent the combined efforts of the entire Department which were approved by the Highway Engineer before being used; also, the equipment and different methods specified to be used were only incorporated in the specifications after joint conferences with the various material men, equipment manufacturers and contractors. One reason for desiring the use of the sub-grader is based on the fact that it is very seldom that we have found that the pavements have the required thickness at all points. Certain slabs in some jobs were found to be only 4 in. thick instead of 6 in. The contractor assumed he had the required thickness, but the core drill has shown that this assumption is not very beneficial to the State. Consequently the changes made in our 1922 specifications have most generally been along the lines to assure that the State would get what it is paying for.

Answering Mr. Burke's question, regarding the sub-grader, will state the information we have from those who have used it and the manufacturer, is to the effect that traffic can pass by this sub-grader on any road eighteen feet or more in width. Consequently, materials can be delivered to a concrete mixer over a subgrade on which this sub-grader is being operated.

MR. BURKE: If a contractor will give 4 in. or 6 in. he can do it just as well with a sub-grader as any way else. Contractors do not go out with the intention of putting 4 in. instead of 6 in.

MR. GAGE: I am not disputing the contractor's intentions, but I am telling you what we have found. It may be that the contractor was not there when the defective pavement was constructed which usually appears to be the case.

MR. HOWARD: I had an opportunity to examine quite a lot of concrete road work in this State last summer and observed that the lower portion of the concrete got more or less mixed with the sub-grade. The water was absorbed by the sub-grade and there was not enough left for the concrete. With concrete 6, 7, or 8 in. thick there is always that layer of 1 in. or 1½ in. or over of weak concrete. It is due to getting it mixed with the sub-grade and the sub-grade absorbing the water which should have gone to the cement. It is wise that the sub-grade should be quite moist to insure plenty of water there to cure the cement and not have it absorbed away by the sub-grade.

As to the requirements of what machinery and tools should be used by the contractors. We cannot dictate to the contractors what tool they shall use. The State requires him to construct a certain structure, but should not state what tools shall be used in its construction. The contractor has a legal right to use any tool. I have in mind a case where a contractor insisted on mixing concrete with shovels. The case was taken into court and it was decided that it was the business of the engineer to see that the concrete was thoroughly mixed and held that the mixing method was the right of the contractor. The use of concrete mixing machines written into specifications have been thrown out, as the State could not dictate how it should be mixed. I warn you, do not dictate what machinery to use, how to grade, and how to mix. It is absolutely impossible to sustain your action if the contractor rebels. A sub-grader is splendid in the open country where there are uniform conditions. In the middle West it works out very efficiently. Be sure the specifications as they are written are right as to the quality of materials to be used.

COL. WHITTEMORE: The remarks heard suggest to my mind similar conditions. On Long Island some people attempted to build a reservoir. The specifications were very voluminous and exacting, and the contractor, I do not hesitate to use his name—Freil—insisted that they should have the full number of inspectors to see that the specifications were carried out to the fullest particular. In the end, it was said the contractor must guarantee the reservoir would hold water. They never were able to make it hold water. They held back from the contractor $300,000. He proved that he had complied with every particular of the specifications and the court and jury held that as he had complied with all the requirements, because the reservoir would not hold water was the fault of the specifications and not the fault of the contractor, and he got his money with interest.

In Massachusetts some misguided men undertook to tell a contractor how to do his work. He promptly told them he was under bond to do the contract, with sureties, and he was required to do the work and not the inspector. It seemed to create a new idea among those who were trying to interfere with the contractor. See that the specifica-

tions are complied with but otherwise don't interfere with the work of the contractor.

MR. GAGE: Are Mr. Howard's statements based on concrete pavement or concrete base?

MR. HOWARD: The particular job I have in mind is a concrete base on which I made a very thorough examination.

MR. GAGE: Mr. Howard's statements do not agree with the results secured with the core drill. Where the excess water was absorbed out of the concrete by the sub-grade, the quality of the concrete has invariably been improved. It would thus appear that it would be beneficial not to wet the sub-grade, but permit it to absorb the excess water in the concrete. This, we have tried, but unfortunately this absorption produces cracks in the bottom half of the slab which will eventually extend through to the surface. It has also been noted, that, when a method of finishing is followed, which accumulates the excess water in the upper half of the pavement without removing it, such as is frequently done with the finishing machine, the strength of the concrete in the upper half of the pavement will be less than that of the bottom half.

MR. TEMPERLEY: I would like to ask a question. Where concrete pavements are laid with a center joint it is not quite clear in my mind, how you increase the transverse strength four (4) times.

MR. WHITCRAFT: The statistics compiled by several states show the amount of transverse cracks to be greater in one state than in another. Pennsylvania has not been carried away with the idea of the center joint because the pavements do not show enough cracks to make it worth while. This question was considered in connection with local conditions. However, I believe the adoption of these features are well justified in New Jersey. The results that you get over a period of years determine this As I said, Pennsylvania did not think they were justified in going to the expense involved to offset the number of cracks that they have.

MR. TEMPERLY: I do not quite get how this joint increases the transverse strength four times.

COL. WHITTEMORE: I will now call the discussion to a close because it has become about mechanics and not about concrete.

Maintenance of Macadam Roads

By W. A. Van Duzer
Asst. Maintenance Engineer Pennsylvania State Highway Dept.

Several of the states, particularly those in the East, have large mileages of stone and macadam highways. This is accounted for, in a measure, by the construction of toll raods during the forepart of the nineteenth century. These were augmented from time to time by the building of this type by townships and counties.

Previous to the advent of the automobile this road answered every purpose. With the intensive auto traffic and general adoption of the motor truck for local and long distance hauling, road authorities were confronted with the immediate necessity of building roads or repairing those already in existence to meet these modern traffic conditions.

There was a general clamor from all parts of the country for continuous mileages of smooth riding pavement. It was early seen that with the methods employed, the construction of the old type of waterbound macadam was obsolete, but with the perfecting of scarifiers, stone crushers, and other modern road building equipment, it became possible to improve the large mileage of stone roads in such a manner that, with but very few exceptions, they have stood up remarkably well. This success has been possible by early determining to use *large stone* macadam, thoroughly bonded and cured and preserved by a consistent policy of surface treatment.

Webster's definition of maintenance is "To hold or keep in a state of efficiency," also "not to suffer to fail or decline." In this paper we will discuss only the special points which enter into the economical maintenance of the waterbound macadam type of pavement.

Resurfacing

The following actual operations enter into the resurfacing of a macadam road: The preparation of the base, which includes: rebuilding of weak spots; sub-draining springs or spongy places; grading to take out depressions; and scarifying to form a uniform cross section, so that an even depth of ballast can be spread. One of the most important points in this preparatory work is to have all pipes and drainage structures placed in advance of actual resurfacing so that the necessary back fill will have had time to settle.

The ballast used in Pennsylvania must meet the following requirements: It must consist of clean, tough, durable crushed rock, with a French coefficient of not less than 10 and shall be uniformly graded and of such size that it will pass over a screen having circular openings of not less than 1½ inches, and through a screen with circular openings not more than 3½ inches in diameter, our preference being to use as large a size as possible depending upon the finished depth of surface to be laid.

The screenings shall consist of material prepared by crushing rock of approved cementing quality, free from dirt and other foreign substances. It has been our experience that screenings with a large percentage of dust, give better results, in that the voids are better filled, and the tendency to ravel before surface treatment is considerably lessened. The chips fill the top voids and prevent the dust from going to the bottom with a consequent loosening under traffic.

The general practice is to place the ballast ahead of the section where it is to be eventually used. The screenings are dumped to the side on the previously prepared shoulder. This is done so that each will be spread as necessity requires. The finished work more than justifies this additional expense. Some success has been obtained by special spreading devices used in connection with dump trucks.

The ballast is thoroughly dry rolled with a 3 wheel 10-ton power roller until the stone does not creep or wave under the action of the roller. The screenings should then be spread fan-wise from a shovel and thoroughly broomed into the voids in the stone, the rolling to continue from the sides toward the center until all voids are thoroughly filled, but no appreciable mat formed. The water is then applied ahead of the roller, and the rolling continued until a grout is formed. This grout flushes to the top, and is evenly spread over the roadway by the action of the roller. While it is not absolutely necessary, we believe it is better if the road is allowed to dry before being thrown open to traffic.

We have tried to cover the materials and methods used in the construction of a first class macadam road, inasmuch as economical maintenance can be built into a highway by the exercise of judgment. This judgment is based on experience as to what will give longest life in connection

with subsequent maintenance, which consists, to a great extent, of proper surface treatment and intelligent and careful patching.

Surface Treatment

Before the application of the surface treatment a macadam road should be cured by the action of traffic for at least two months. The maintenance during this time consists principally of sweeping, either by caretakers, or lightly by mechanical broom or horse-drawn sweeper. This sweeping is done for a dual purpose: First to remove the cake or matted screenings from the edges. This we deem is extremely important, and unless care is used will necessitate extra treatments. Second to place these screenings in the center of the highway, where they have been removed by the action of traffic. The screenings which are swept back to the center will prevent the road from ravelling and assist in curing it. Under exceptionally heavy traffic it is found necessary to add dry screenings and occasionally during hot dry spells the sprinkler can be used to advantage both in holding the road and assisting in the curing action. But, under no circumstances should a road which is not broken up be re-rolled, as this breaks the bond and destroys the value of traffic curing action.

Previous to the first application of bituminous material, which we believe should consist of a low viscosity tar, in order that a maximum penetration can be obtained, the screenings must be removed by sweeping so that the voids will show between the ballast to a depth of possibly ¼ of an inch. The tar should be appplied in two treatments by a pressure distributor, if possible, or other mechanical means. The first application to be approximately 1-3 of a gallon to the square yard and the second from 2-10 to ¼ of a gallon per square yard. Our experience has been that a third of a gallon applied will penetrate the road. The second application will heal up the spots that are not thoroughly bonded or are loosely bonded, but will not fill the voids, and leaves the ballast to take the wear with the tar as a binder. The second application may be either a high viscosity tar or asphalt and the quantity should be just enough to fill the voids, which can only be determined from experience, but usually runs from .25 to .3 of a gallon per square yard. On a road that carries extremely heavy traffic we occasionally skid chip it on the first application, that is apply from 3 to 10 pounds of chips to the square yard as a safety measure, particularly on heavy grades and narrow roads.

Hard stone chips ranging in size from ¼ inch to 1 inch in size, dustless, and free from dirt, should be used with the second treatment, at the rate of 20 to 30 pounds of chips per square yard or approximately one cubic foot of stone chips to one gallon of bituminous material. Owing to the large chips used and to assist in pushing the chips into the bituminous material, the treatment should be rolled either with a 5 to 8 ton tandem or 10 ton macadam roller. The roller can be used as soon as the chipping is completed, but equally good results are obtained if the road is rolled 24 to 36 hours later, if a rapid drying bituminous material is not used.

We have obtained the best results by three successive treatments. The third treatment may be either a high viscosity cold tar, water gas tar or asphalt, or as an alternative a hot asphalt having an asphaltic content of 88 to 95 at 100 penetration, or a consistency (float test) of approximately 150 sec. at 50 degrees centigrade. We apply from .15 to .25 of a gallon per square yard, which requires from 30 to 40 pounds per square yard of covering material. This treatment must be watched carefully, as the roadway will bleed after it is thrown open for traffic, and, if not given proper care by application of chips, will pick up badly under steel tire wagon traffic. If the treatment is made late in the fall it may require rechipping after the beginning of hot weather in the spring.

Caretakers

The necessity for uniform continuous maintenance is probably greater for the waterbound macadam type of construction than for any other. The advantage of thoroughly experienced workmen is unquestioned and considerable care must be exercised in picking the organization and seeing that proper instructions are issued covering each phase of the maintenance work.

There are two general systems recommended for carrying on the maintenance of these roads, both of which have their advantages. They are the caretaker or patrolman, and the patrol crew or gang. The first is closer to the ideal if properly controlled. This plan arranges the road mileage in sections of from three to five miles in length with a patrolman, properly provided with tools, materials, etc., whose duty it is to keep up the small repairs and emergency work, and with authority to hire additional men, teams, etc., when instructed by their immediate superior. These caretakers keep the surface patched and all depressions filled; see that the side gutters and cross drains are kept open; paint slight surface depressions and sprinkle with chips tamped in place; larger depressions are filled with larger stone and topped with patching tar and chips, the mix being in a proportion of 1 to 12, or 1 to 14, depending to some extent upon the weather. In case of failures due to stopped drains or springs the whole section is dug out and drainage placed leading to the gutter or culvert and large stone laid to bring up the base. The ballast and screenings are hand tamped in place if no roller is available and the spot painted and given a mixed patch of tar and chips.

These patrolmen file daily report cards, giving the nature and extent of the work, hours engaged and particular kind of work performed, in order that the cost data may be properly computed.

The patrol gang is an organized force of picked men, provided with tools, materials, etc., to maintain road mileages of various lengths. As far as overhead expenses are concerned it is possibly more economical than the caretaker system, the men being well trained and efficient for each class of repair work. The difficulty, however, is that a force of this kind cannot give each section the required attention, especially in emergency cases. The work cannot be accomplished simultaneously as in the caretaker system, which we deem is the real factor to be desired. The gang system, is, however, an insurance against shortage of labor upon those sections of the road that are removed from the thickly populated districts. The matter of control of a force of this kind can be taken care of by a full report of the operations and the expenses of the work. This method was used by us to a great extent in the past few years on account of the labor shortage during and directly subsequent to the war.

Maintenance of Second Class Macadam

Naturally where so many miles of road have to be maintained a highway department must have a large mileage of ordinary stone, or second class macadam roads, the maintenance of which is entirely different from the rebuilding operations covered previously except as to general repair operations.

In certain rural sections where the travel consists mostly of horse drawn vehicles, the ordinary stone roads are kept up merely by an application of stone which is edged by dust or side material to keep the larger stone in place while the action of traffic and weather cements it. When this method is used it is sometimes called, for want of a better name, Unbound Macadam. The size of stone used in this class of work is from ½ inch to 1½ inch, with dust removed as it only sifts to the bottom and is of no value, and a sufficient quantity of dust is formed by traffic to hold and cement the ¾ inch stone in place.

When a road has been brought up to an approximately uniform cross section and grade by local treatments of stone, just referred to, and traffic conditions warrant, an application of a high viscosity tar is given at the rate of 1-3 to 2-3 of a gallon per square yard, the larger amount in two applications, the rate to be governed by the depth of loose stone and to be varied accordingly. In this manner a road may be kept in comparatively good riding condition for a few years until funds are available for a more permanent type of construction.

Discussion of Mr. Van Duzer's Paper

By A. W. Muir
Supt. of Maintenance New Jersey State Highway Department

I feel that Mr. Van Duzer has presented a paper which is worthy of serious consideration and study by all persons concerned in the maintenance of highways whether on the State Highway System, or in the Counties or municipalities. The mileage of water-bound macadam at the present time is so greatly in excess of the mileage of higher type pavements through the State that the problem of maintaining such pavements is one of prime importance. What Mr. Van Duzer has told us in this paper comes with especial weight, due to the fact that the Pennsylvania Highway Department has been notably successful in the maintenance of water-bound macadam. While the large stone macadam has been used in Pennsylvania for some years, to the best of my knowledge, it has been used but little in the State of New Jersey, and, in fact, I believe but little is known of its use in this State. I might go even further than this and state that, to the best of my knowledge, the only time that the large stone macadam has been constructed in New Jersey was during the season of 1921, when some twelve to fifteen miles were constructed on State Highways with very good results. When starting the use of the large stone macadam, it was found that there was considerable opposition to the use of the large stone by the men doing the work in the field, which opposition was, without question, founded upon preconceived notions as to the proper materials for the construction of water-bound macadam, and the further fact that it is undoubtedly considerably easier to make up water-bound macadam with the use of smaller stone, which ease of construction is, however, in my opinion, very decidedly offset by the greater rapidity of deterioration under present day traffic. This opposition to the use of the large stone, it was found, very soon disappeared, and from opponents to the use of large stone, the field men rapidly developed into enthusiastic advocates, some even going so far as to say that they never wanted to use anything but large stone in the future.

I feel that Mr. Van Duzer has covered the subject in a general way to very good advantage. There are, however, a few points upon which I should like to ask him some questions in order to bring out certain points which are not clear to me, or which may not be clear to those who have had no experience in the use of the large stone. It will be noted that what Mr. Van Duzer terms large stone macadam is macadam constructed from a material the grading of which very closely complies with the 1922 specifications for two and one-half inch stone in New Jersey. Mr. Van Duzer's grading is over a screen having circular openings of not less than one and one-half inches and through a screen with circular openings of not more than three and one-half inches in diameter.

The new grading for what is known as two and one-half inch stone in New Jersey is as follows: One hundred per cent through a three and one-half inch ring; ninety to one hundred per cent. through a three inch ring; zero to twenty-five per cent, through a two and one-half inch ring; and zero to five per cent. through a one and one-quarter inch ring.

One of the problems which has confronted the State Highway Department in its construction of large stone macadam has been the procuring of a sufficient supply of screenings for binding up the large stone. I note that Mr. Van Duzer states that the screenings shall consist of material prepared by crushing rock of approved cementing quality free from dirt and other foreign substances. The great difficulty in New Jersey has been to get screenings which are free from dirt and other foreign substances. There is an ample supply of screenings which have an average of possibly twelve per cent. of dirt and other foreign substances, but screenings which will comply with Mr. Van Duzer's specification seem to be available to an extent of not over twenty-five per cent of the demand. The Department during the past season received a car load or two of screenings from a Pennsylvania producer which I was advised were the same material as is in use on the Pennsylvania Highway Department work, but these screenings were found to be anything but free from dirt and other foreign substances, and when used, produced a result very similar to results which would be obtained by the use of a percentage of earth binder. The question has, therefore, arisen in my mind as to whether this specification is to be interpreted as meaning commercially free from dirt and other foreign substances, or whether a strict laboratory interpretation is to be placed upon the specification.

If I understand Mr. Van Duzer clearly, the practice in Pennsylvania is to dump both the ballast and screenings in piles ahead of the actual points where the material is to be used, and it is then spread from these piles by hand. In this connection, I should like to ask as to the amount of additional expense incurred by this practice, and what, in his opinion, are the advantages accruing from this method of handling the work.

The manner of rolling and spreading of screenings is, in my opinion, of utmost importance. I feel that unless this portion of the work receives very careful attention, the best results will not be obtained. I feel that Mr. Van Duzer's point in regard to the forming of a mat should be particularly stressed. It is my observation that there is a very strong tendency among the men in the field to apply the screenings in too large quantities, with the result that a fine surface is obtained temporarily, but that instead of having a thoroughly bound up macadam, the real result is a mere crust on the surface which soon disintegrates, followed very rapidly by the insufficiently bound large stone. This last point has a particular bearing upon the next portion of Mr. Van Duzer's paper; namely, the matter of surface treatment. Many of the men in the field are of the opinion that it is necessary to follow up the completion of their work almost as rapidly as possible with a surface treatment in order to hold the road, this being in direct contradiction to Mr. Van Duzer, who holds that a macadam road should be cured by the action of traffic for at least two months before the application of any bitumen. It is my belief that this latter point has been very thoroughly covered by Mr. Van Duzer in his outline of the procedure to be followed in patrolling the finished work during the interval between its completion and the application of the bitumen, and that the success or failure to obtain a properly cured pavement lies in the care with which the patrolling is carried out. The point which Mr. Van Duzer makes as to rerolling of a road is of particular interest, as the statement is often heard that a macadam road cannot be rolled too much.

Having formed and cured our water-bound macadam, Mr. Van Duzer now comes to the matter of surface application. I should like to underscore particularly one point which he makes in regard to the preparation of the surface by sweeping; namely, the matter of the removal of screenings on the surface. It is my belief that a very large portion of the scaling off of surface treatment is due to no other cause than the fact that small patches of the crusted screenings have been left on the surface, which crust becomes loosened from the large stone under traffic, and fine cracks are formed which allow water to penetrate, with the resultant peeling off of the surface treatment. This, I believe, is borne out by the fact that such failures in surface treatment show up to only an almost negligible amount in dry weather, but are very apparent immediately after a rainy day.

Mr. Van Duzer has sketched for our information the procedure in Pennsylvania in surface treating water-bound macadam, but there are one or two points in connection with the treatment which I shall be glad if he will bring out somewhat further: First, the interval between the successive treatments; second, if any cover applied on the first treatment, and if not, is there not considerable complaint from the public owing to this practice; third, I shall

be glad if he will give us the analyses of the different grades of material used in Pennsylvania, as it is my understanding that, particularly in the tars, Pennsylvania uses at least one grade of material not in use in New Jersey. I might say in passing that any information which Mr. Van Duzer can give the Convention on surface treatment will, in my opinion, be well worth receiving, as Pennsylvania has many miles of surface treatment work which the casual observer might easily mistake for bituminous concrete, and which are excellent examples of the results which it is possible to obtain from proper application of surface treatments.

Mr. Van Duzer, in his outline of maintenance of surface treatments, has sketched for us the most generally accepted methods of caring for surface treatments, and pointed out quite clearly the advantages of the different methods.

I regret that Mr. Van Duzer has not devoted more time to the matter of the maintenance of what he terms "Second Class Macadam", as I believe the methods in use in Pennsylvania are practically unknown in New Jersey, not so much in regard to the aggregates used in this work, but particularly in regard to the use of bitumen. The method of constructing unbound macadam is, I believe, a distinct innovation in the handling of broken stone roads, and where traffic conditions warrant its use, I believe that Pennsylvania's experience will warrant authorities in charge of such roads in adopting the method.

COL. WHITTEMORE: Gentlemen, this is an exceedingly important subject, suggesting a great many questions which I know will be presented. This interesting discussion might extend until the dinner bell tonight. It is nearly 12 o'clock now, but if there are any questions pertinent to this subject, I am sure Mr. Van Duzer will be glad to answer them to the best of his ability.

MR. GAGE: This method of reconstruction is comparatively new in this State yet the Highway Department has had specifications defining it for over three years. An effort has been made to have it adopted and used by the various counties as well as our own Department, but apparently very few saw any merits in it and would not believe that desirable results could be secured by such a method.

In the preparation of our specifications defining the various sizes of stone to be used, this method was kept constantly in view for we realized that the time was not very far off when it would have to be adopted. Consequently, the stone required for this method of construction is the next size larger than that required for use in concrete. A few years ago, the writer inspected a quarry where they had a very large stock pile of 2½ in. stone and they were then crushing this size stone to increase their output of ¾ in. stone. During the past season, I believe, the Department had difficulty in securing deliveries on 2½ in. stone for apparently the demand exceeded the supply.

It is certainly very gratifying to have Mr. Van Duzer present their experience with this method of construction in such a manner that hardly anyone can doubt its merits. Mr. Muir's experience of last year showed that the State was fully justified in adopting this method of construction.

When the proper care is taken to see that the 2½ in. stone is thoroughly bonded and the top surface is free from all binding material or dust when the initial bitumen is applied, there is little doubt but that satisfactory results will be secured. It is, however, very regrettable that we do not have more time to discuss the light oil treatment, especially that of tars on macadam roads. I am afraid that many who have heard this lecture may think that it is necessary to use more tar or oil per square yard of surface treatment than what is really required. It is very important that the quantity used be the minimum amount in order that a bituminous layer will not be built on top of the larger size stone.

The methods in general use in this State for surface-dressing an old macadam road have been to apply a certain quantity of oil each year with the necessary metal covering. This method has gradually built upon on the old macadam roads a bituminous layer which in many cases is from three to four inches in thickness and is composed principally of screenings and bitumen. Each year this layer develops more pronounced bumps and depressions than in previous years and apparently each treatment increases these bumps and deepens the depressions. This type of pavement surface might be satisfactory in some localities where the inhabitants are not accustomed to any better types of road, but it is certainly not satisfactory to the majority of autoists in New Jersey.

There is no denying the fact that our macadam roads are not properly maintained. It is foolish to assume that we can constantly go on patching and re-patching them in the manner we have been doing for the last five or ten years. Some definite method of reconstructing them will have to be adopted and it is quite evident that, since our mileage of this particular type of road is exceedingly large, the cost for re-building them will have to be reduced to a minimum. It is the writer's belief that the above method described by Mr. Van Duzer will be found the most suitable and economical to be used for this purpose in the majority of cases, and, if generally adopted in the near future, it will mean a tremendous saving in the cost of maintenance of our macadam roads during the next few years; also, if at any time it is found that this type of construction cannot be economically maintained on account of the heavy traffic conditions, very little extra expense will be required to put this surface in condition to be used as a foundation for a bituminous pavement of the mixed type. It certainly will be a better macadam base than that now being used for the 2½ in. stone is more firmly bound together and nearly waterproof to the passage of underground waters.

We certainly should take the utmost advantage of Mr. Van Duzer's paper and see that the Counties and Townships are supplied with copies of it.

Mr. Muir, I am quite sure, is well satisfied with the results obtained by this method of construction and will not dispute the economic advantage to be secured by the use of the larger size stone. As I have previously stated, there is a tremendous mileage of County and Township roads that should be re-surfaced in the near future and the writer believes that the Department should exert their utmost efforts in having the various Counties and Townships adopt this method. It certainly does make a very desirable type of pavement for ordinary motor traffic. It, no doubt, will reduce the quantity of certain types of road material to be used, but roads should be constructed more for the benefit of the traveling public than for the material men. It is recommended that Mr. Van Duzer's paper be reprinted in our Highway publication, known as the HIGHWAYMAN.

MR. STANLEY: Mr. Muir asked a question in his paper that I would like to have answered.

MR. VAN DUZER: With reference to the first question about spreading the stone: Does the re-handling of the stone get results and do we get results that justify the expense? I believe we do. By hauling stone with trucks, the old method was to raise the dump body and spreading the stone along the road. Very often the stone stuck and you had a bump. You either had too much stone or not enough. Our idea is this: If you can spread and handle all the stone you will keep away the segregation and get a uniform surface. We also use a template on our subgrade and also on the finished road, also a 10-foot straight edge. There will be enough waves in a macadam road anyway, and we must take into consideration the kind of men we have working for us and every mechanical means that you can get should be put into the foreman's hands to save labor, so that there is much more assurance of getting a real road when you get through. As far as expense is concerned, it really means only one or two additional men. We usually have about 5 men for laying from 200 to 250 feet a day, and it takes about 40 or 50 ton to the 100 foot. It does not cost over $200 to $300 per mile, and $200-$300 per mile is not out of proportion when we sometimes spend $7,000 or $8,000 per mile for maintenance.

Another point questioned by Mr. Muir was surface treatment and I want to clear this up in connection with how far apart to make the applications of this treatment. If the road is built early in the spring, that is, if it is completed along in May, we generally give a treatment probably the latter part of June or the middle of July, and that is our priming coat. If the road is carrying exceedingly heavy traffic, we will probably put on the second treatment along in September or the first of October. We do not believe it is good business to put on the second

treatment later than October because the road, unless the road is carrying extremely heavy traffic, will probably work out better if you will give a treatment in the spring.

The third treatment should follow the next year. It can be either hot asphalt or of a high viscosity tar, or cut-back asphalt. Our specifications are practically the same for our second treatment as the Tarvia B. On our asphalt we have changed the specifications this year and are using practically the same base as we use in hot asphalt, and cutting back with naptha. We find that this material then will give consistently results and usually cures in from three to four days after applications. Mr. Gage brought out a good point, and that was not to get too much bituminous material on the road. It is not a hardship on the material men if they do not sell so much of their material, because if you can show that you are getting real results with that type of pavement you are going to create a natural sale for more material and that type of pavement will grow. The material men are all interested in seeing that their material is used to the best advantage. Put on as light a treatment as possible and keep a mat off the road. Have the large stone sticking through. Fill up to the top of the stone, but don't get a mat on the stone.

COL. WHITTEMORE: I think it would be of advantage to the audience if you would make some mention of the thickness. The size of the stone would undoubtedly have some bearing on the thickness of the repair in resurfacing work.

MR. VAN DUZER: We use about 6 in. of stone from 2¼ in. up. We believe we get better results with about 6 in. for depth.

COL. WHITTEMORE: Any other questions?

MR. STANLEY: I would like to ask Mr. Van Duzer if he has any trouble with slabs and elongated pieces in the road-bed.

MR. VAN DUZER: We sometimes use tailings. In the case of slabs, if we come across them, they are broken with a small 8-lb. napping hammer. The foreman can readily pick out these slab pieces.

MR. STANLEY: Do you have trouble breaking them with a hammer, say trap-rock?

MR. VAN DUZER: We have most of our trouble with lime-stone.

MR. STANLEY: Do you build your jobs with detours?

MR. VAN DUZER: We use no detours at all on maintenance work. Pennsylvania is tied up with detours on construction, and we wished to carry on the maintenance work without detours.

MR. STANLEY: Does 6 in. minimum make a good job?

MR. VAN DUZER: Yes.

MR. NEWMARK: 6 in. applied in one course?

MR. VAN DUZER: Yes.

MR. NEWMARK: What weight per square yard of stone would you recommend to put on surface treatment, that is for covering with surface treatment?

MR. VAN DUZER: From 20 to 30 pounds depending upon the treatment. As light a covering as possible, however.

MR. STANLEY: What size screenings do you use for waterbound macadam?

MR. VAN DUZER: From dust up to ⅜ in.

MR. STANLEY: What weight?

MR. VAN DUZER: What percent in weight? 50%.

COL. WHITTEMORE: That seems to be all the questions.

For You—
"The Highwayman"

Do you use roads? Do you want to know where they are being built, and what detours to take, each month.

Then send, TODAY, to

The Highwayman
New Jersey State Highway Department
Trenton, N. J.

Just ask ro be put on the Highwayman's list. A postal will do.

MONTHLY BULLETIN OF DETOURS

Adopted by the New Jersey State Highway Commission

Corrected to July 10, 1922

All detours posted with signs and blazed with "Arrows"

Note:—The traveler will find poles banded along each route of the State Highway System to correspond to the colors indicating the direction of the routes.

Blue on the posts or signs indicates that the road is running **North** and **South.**
Red shows that it lies **East** and **West.**
While **Yellow** tells you that it takes a diagonal course **Northwest** and **Southeast.**
Brown indicates that it takes a Diagonal course **Northeast** and **Southwest.**

ROUTE NO. 1—Westfield Avenue, City of Elizabeth.
Under construction. Traffic will detour as follows:
EAST BOUND, follow Cherry Street to Orchard Street, to Prince Street, to North Broad Street.

WEST BOUND, on Prince Street from Broad Street to Orchard Street, to Cherry Street, to Route No. 1.

ROUTE NO. 1, Section 6—Greenwood Avenue near the City of Trenton
Under construction. Traffic will detour beginning near the City Line of Trenton at the intersection of Greenwood and Olden Avenues, thence northerly over Olden Avenue to East State Street thence easterly on East State Street to Nottingham Way, thence southeasterly on Nottingham Way to Greenwood Avenue and Bromley Inn.

ROUTE NO. 2, Section 3—South Broad Street, Trenton.
Under construction. No detour necessary. Traffic will go through construction.

ROUTE NO. 2, Section 3-A—Under construction between White Horse and Crosswicks.
No detour necessary. Traffic will go through construction.

ROUTE NO. 3, Sections 8, 9 and 10—Under construction between Camden and Berlin.
Traffic to the Shore from Market Street Ferry, Camden, will go out Federal Street to Haddon Avenue to Mt. Ephraim Avenue, thence over Mt. Ephraim Avenue through Mt. Ephraim, Chews Landing, Blackwood and Clementon to Berlin.
Traffic from the Shore will leave the White Horse Pike at Berlin going through Gibbsboro, Haddonfield, Ellisburg and over the Marlton Pike to Federal Street, Camden, thence over Federal Street to the Market Street Ferry.

ROUTE NO. 4, Section 5-A—Maple Avenue, Red Bank.
Under construction. Detour beginning at Maple Avenue and Front Street, thence over Front Street to Broad Street to Bergen Place and Route No. 4.

ROUTE NO. 4, Sections 6 and 10—Under construction between the Eatontown-Long Branch Road and Allenhurst.
Detour at Eatontown over South Street, thence over road leading to West Long Branch to Whale Pond Road, thence along same to Poplar Avenue, thence along Poplar Avenue to Locust Avenue, Oakhurst, thence along Locust Avenue to Roseld Avenue, Deal, thence along Roseld Avenue to Richmond Avenue, thence on Richmond Avenue to Darlington Road, thence on Darlington Road to Norwood Avenue, and Route No. 4.

ROUTE NO. 4, Section 11, Avon-by-the-sea, under construction.
No detour necessary. Traffic will go through construction.

ROUTE NO. 4, Section 13—Point Pleasant Beach, under construction.
Detour beginning on Route No. 4 at the intersection of Richmond Avenue and River Avenue just south of the Manasquan River Bridge, thence southerly over River Avenue to Arnold Avenue, thence westerly and southerly over Arnold Avenue to Pine Bluff Avenue, thence westerly over Pine Bluff Avenue to Osborne Avenue, thence southerly on Osborne Avenue to Route No. 4 in West Point Pleasant.
Detour on account of construction of bridge at Inland Waterway, West Point Pleasant, for local traffic, beginning at the intersection of Route No. 4 and Arnold Avenue, West Point Pleasant, and running thence northerly on Arnold Avenue to Pine Bluff Avenue, thence westerly over Pine Bluff Avenue to Osborne Avenue, thence southerly over Osborne Avenue to Route No. 4 in West Point Pleasant.

ROUTE NO. 4, Section 14—Under construction between Laurelton and Lakewood.
Detour beginning at intersection of Route No. 4 and Cedar Bridge Road at Laurelton or Burrsville, thence southerly through Cedar Bridge and Silverton to Hooper Avenue, Toms River, thence westerly over Hooper Avenue to Washington Street, thence westerly over Washington Street to Robbins Street, thence southerly over Robbin's Street to Water Street, thence westerly over Water Street to Route No. 4, Toms River.

ROUTE NO. 4, Section 15—Lakewood, under construction.
Detour beginning at Route No. 4 on River Avenue and Central Avenue, thence westerly over Central Avenue and the Lakewood-New Egypt Road to Cross Street, thence southeasterly over Cross Street to the Lakewood-Toms River Road or Route No. 4.

ROUTE NO. 4, Section 16—Toms River, under construction.
Detour beginning at the intersection of Route No. 4 and Maple Street, Toms River, thence easterly over Maple Street to the old Toms River Road, thence southerly over the same to Chestnut Street, thence easterly to the Laurelton-Toms River detour thence southerly to Toms River.

Over

ROUTE NO. 4, Section 17—Barnegat, under construction.
No detour necessary. Traffic will go through construction.

ROUTE NO. 4, Section 18—Tuckerton, under construction.
No detour necessary. Traffic will go through construction.

ROUTE NO. 5, Section 5—Convent Station to Madison.
Detour beginning at the corner of South Street and Madison Avenue, Morristown, and running from thence on South Street in a southerly direction to the Morristown-Green Village Road; from thence still southerly on the Morristown-Green Village Road to Loantaka Way; thence easterly on Loantaka Way to Woodlawn Road; thence still easterly on Woodlawn Road to the Madison-Green Village Road; thence northeasterly on the Madison-Green Village Road to Kings Road; thence southeasterly on Kings Road to Waverly Place; thence easterly on Waverly Place to Route No. 5 in Madison.

ROUTE NO. 5, Section 9—Under construction between Barker's Corner to Hackettstown.
Detour beginning on Route No. 5 known as Mill Street, Hackettstown, at the intersection with Water Street, thence over Water Street to Mountain Avenue, thence northerly on Mountain Avenue to Little Street, thence westerly on Little Street to Washington Street, thence northerly on Washington Street to Moore Street, thence easterly on Moore Street to Main Street and Route No. 5.

ROUTE NO. 6, Section 14, Broad Street, Woodbury.
Under construction from railroad crossing at north end of town to Red Bank Avenue. Detour north end from Westville on Westville-Glassboro Road to Cooper Street to Broad Street, Woodbury.

ROUTE NO. 6—Manuta Avenue, Woodbury.
Under construction from Broad Street south to present improvement. Detour at Broad Street and Barber Avenue, thence on Barber Avenue to Woodbury-Glassboro Road to Woodbury Heights, thence to Mantua and Route No. 6.

ROUTE NO. 6, Sections 5 and 6—Under construction between Mullica Hill and Shirley.
Detour via Woodstown, Alloway and Aldine to Bridgeton.

ROUTE NO. 6, Section 9—Under construction between a point south of Woodstown (Cullier's Run) and Salem.
Detour beginning at a point south of Woodstown to Sharptown and Salem. Traffic will be maintained over a portion of the highway under construction from a point 1½ miles north of Salem to Salem.

ROUTE NO. 6, Sections 10 and 11—Under construction between Salem, Quinton and Bridgeton.
Detour from Salem through Hagerville, Hancock's Bridge, Harmersville, Canton, Gum Tree Corner and Roadstown to Bridgeton.

ROUTE NO. 9, Section B—Plainfield, under construction.
Detour beginning at Route No. 9 or Plainfield Avenue and go over Muhlenberg Place to West Second Street, thence over West Second Street to Clinton Avenue, thence over Clinton Avenue to West Front Street or Route No. 9. Traffic will be maintained on West Front Street from Clinton Avenue to the Borough of Dunellen one-half the width at a time.

ROUTE NO. 9, Sections 5 and 6—Under construction in the Borough of Bound Brook and between Bound Brook and Somerville.
Detour beginning on Route No. 9 at the concrete arch bridge approaching Raritan Avenue near the easterly Borough Line of Bound Brook, thence southwesterly over the concrete arch bridge by way of Raritan Avenue and westerly over Main Street, Bound Brook, to Shunpike Avenue; thence following Shunpike and Talmadge Avenues through Bound Brook, and westerly over the New Brunswick Turnpike and East Main Street to Somervville to Route No. 9 at Gaston Avenue.

ROUTE NO. 9, Section 8—Under construction between Somerville and North Branch.
No detour necessary. Traffic will go through construction.

ROUTE NO. 9, Sections 1 and 2—Under construction between Perryville and West Portal.
Detour via Clinton, Glen Gardner, Hampton, Asbury, West Portal.

ROUTE NO. 9, Sections 9 and 9-A—Under construction between Bloomsbury and Phillipsburg.
Detour in Bloomsbury via Stewartsville and Straw Church to Phillipsburg. (Detour may be in effect as soon as this information is in the hands of the traveling public.)

ROUTE NO. 10, Section 1-B—Under construction between Arcadian Way and Anderson Avenue.
Detour over Bluff Road to Anderson Avenue.

ROUTE NO. 11 Section 1—Main Street, Passaic, under construction.
Short detour over local streets.

Market Street, Paterson, under construction (Connecting Routes No. 10 and No. 12).
Detour over local streets.

ROUTE NO. 12, Section 2—Under construction between Parsippany and Denville.
Detour at Cobb's Corner, Littleton, Morris Plains and Tabor to Denville.

(The following detour on Route No. 13 is not marked and is merely suggested.)

ROUTE NO. 13—Which is the Lincoln Highway, is under repair between Lawrenceville and Princeton.
Traffic is advised to detour via Washington Street, Princeton, across Carnegie Lake and the canal to the Brunswick Pike at Penn's Neck, turning south over the Brunswick Pike to the City of Trenton.

NORTH-BOUND TRAFFIC will take the reverse of this route which is out Brunswick Avenue, Trenton, continuing out the Brunswick Pike to Penn's Neck just east of Princeton, where traffic will turn to the west going over the canal and Carnegie Lake through Washington Street to Nassau Street, Princeton, and turning north on the Lincoln Highway and going to New Brunswick.

ROUTE NO. 15, Sections 2 and 3—Under construction between Bridgeton and Millville.
Detour beginning at the corner of Commerce and Walnut Streets, Bridgeton, thence northerly over Walnut Street to Irving Avenue, thence easterly over Irving Avenue and Beaver Dam Road through Carmel to the intersection of Route No. 15 and the Beaver Dam Road near Millville.

ROUTE NO. 16, Section 3—Under construction between Bedminster Corner and Pluckemin.
No detour necessary. Traffic will go through construction.